THE WEATHER AND CIRCULATION OF AUGUST 1959

A Hot Month from the Central Plains to the Atlantic Coast

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1. THE HEAT WAVE IN RELATION TO THE CIRCULATION

August 1959 was an exceptionally hot month for most of the United States. Figure 1 shows that in about three-fourths of the country, monthly temperatures averaged warmer than the seasonal normal. From the Dakotas to the Lower Great Lakes and from the Ohio Valley to the Middle Atlantic States, temperatures averaged from 4° to more than 6° above normal for the month. Cooler than normal weather was confined principally to a patch in the Southern Plains States and to a belt extending from the Pacific Northwest to parts of the southwestern deserts.

Extremely high temperatures did not typify this August's heat wave, but its severity was manifested in other ways. It is best described as one with successive days of discomfort in which maximum temperatures hovered around 90°F., while humidities and nighttime minimum temperatures were both high.

All-time records for number of days with a maximum of 90°F. or more were reported by Cincinnati, Ohio (22 days), Newark, N.J. (15 days), and Boston, Mass. (11 days). Washington, D.C., and Los Angeles, Calif. airports recorded their warmest Augusts of record. At Los Angeles airport monthly mean temperatures have been warmer than the 1921–50 normal since April 1956, a noteworthy climatic fluctuation. Several cities had their warmest August since the heat wave of 1947, and others since 1937. At the other extreme, Miami International Airport had its coolest August of record.

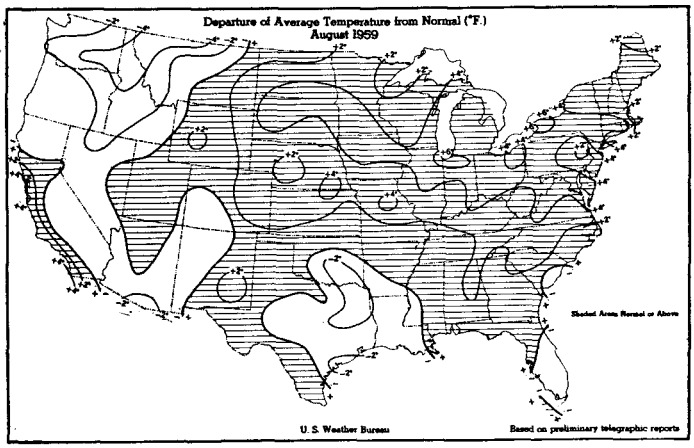

FIGURE 1.—Departure of average surface temperature from normal (°F.), August 1959. Hatching indicates areas of normal or above normal temperatures. Departures of 4° F. or more were common from the Northern Plains to the Atlantic Coast. (From [4] Sept. 7.)

The upper-level circulation at 700 mb. for the month is shown in figure 2. Considering only North America and the adjacent marine areas, the immediate impression is one of a moderate zonal flow with the westerlies displaced well to the north. That condition is not uncommon in the summer months when the subtropical ridge penetrates well into the United States as an extension of the Bermuda High.

The August pattern was generally less complex than that of June [1] or July [2]. The dotted lines in figure 2 represent departures of observed height from normal and thereby show the relative strength of major features. Of considerable importance to the weather in the United States was the lack of amplitude of the wave pattern there. However, the trough in western North America was sufficiently intense to keep the West cooler than normal as the eastern Pacific ridge propelled cool, maritime air into it. Confluence of cool and warm streams of air in central Canada was associated with fast westerlies across Canada, thus precluding strong ridge development north of the United States border. Height departures in the downstream trough off the Atlantic Coast were negative only in its southern portion.

Much of the United States might have been cool instead of hot had there been a mechanism to transport the cool Pacific air deeply into the country. But the combination of the trough in western North America, the ridge in eastern United States, and fast westerlies in Canada was not conducive to the invasion of cool air masses. Even though the ridge was only some 80 feet above normal, its persistence permitted a continuation of warm conditions. The broad southerly flow at sea level (see Chart XI of [3]) supplemented that at the upper level. Its presence

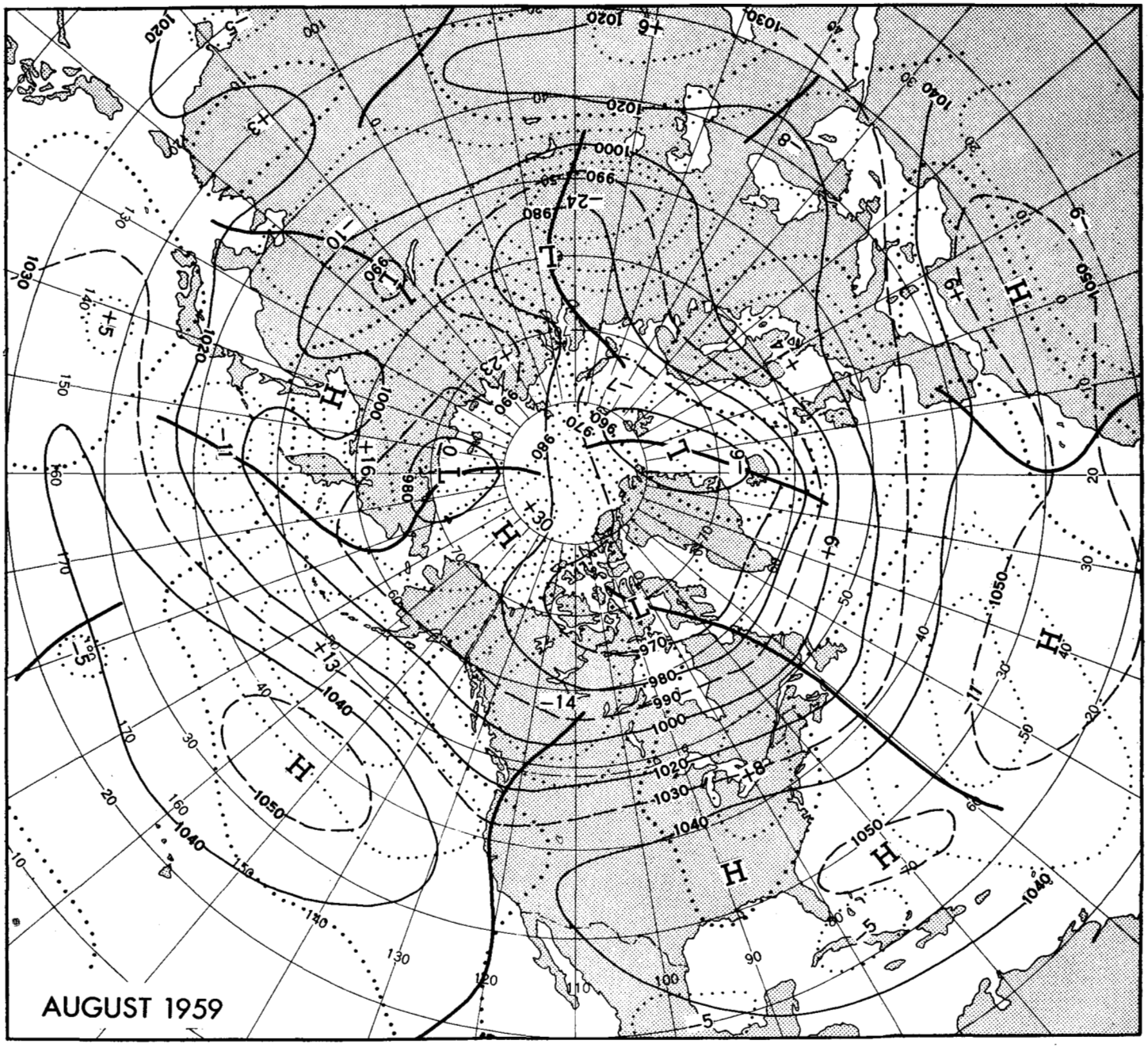

FIGURE 2.—Mean 700-mb. contours (solid) and height departures from normal (dotted) (both in tens of feet) for August 1959. Over the United States and adjacent oceans the westerlies were weak or absent south of 45° N., and the warm, subtropical ridge had a great influence on the weather.

also suggests warming and recurrent thrusts of tropical air east of the Rockies.

Figure 3 is a composite chart prepared from ten cases of heat waves in the northeastern quadrant of the country in June, July, or August selected from the years 1933 to 1958. For this study a heat wave was defined as the predominant occurrence of the much above [1] normal temperature anomaly. In many respects the observed upper-level mean for August 1959 closely approximated the composite (compare figs. 2 and 3).

The composite represents the type of flow in which the polar front may be expected to lie along the northern border of the United States east of the Continental Divide. The absence of a ridge in Canada precludes massive cold advection into the eastern half of the country. The extensive tropical ridge in the southern and central States and the intensified southerly flow insures repeated advec-

[1] Temperature anomalies are divided into the following classes: much above and much below (12½ percent occurrence each) and above, near normal, and below (25 percent occurrence each).

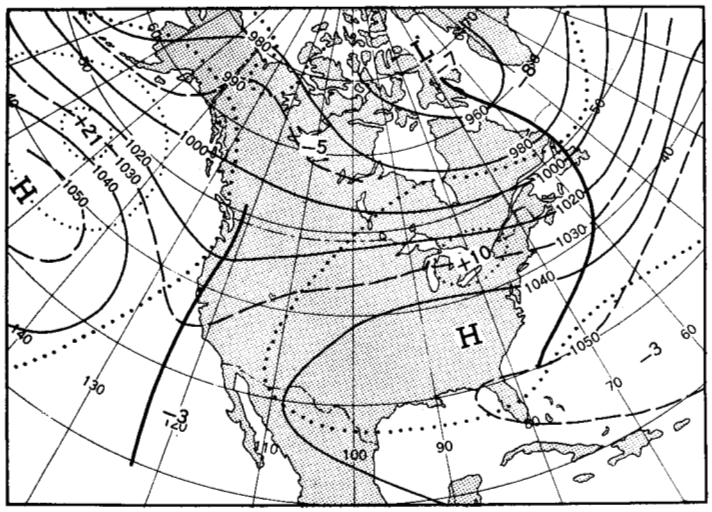

FIGURE 3.—Composite mean 700-mb. contours (solid) and height departures from normal (dotted) (both in tens of feet) for ten selected cases of hot weather in the northeastern quadrant of the United States for summer months (June, July, August) from 1933 to 1959. The obvious features common to all hot spells in the Northeast are: a strong ridge in the Gulf of Alaska, a trough along the west coast, an extension of the Bermuda ridge into the Midwest, and below normal heights in Canada.

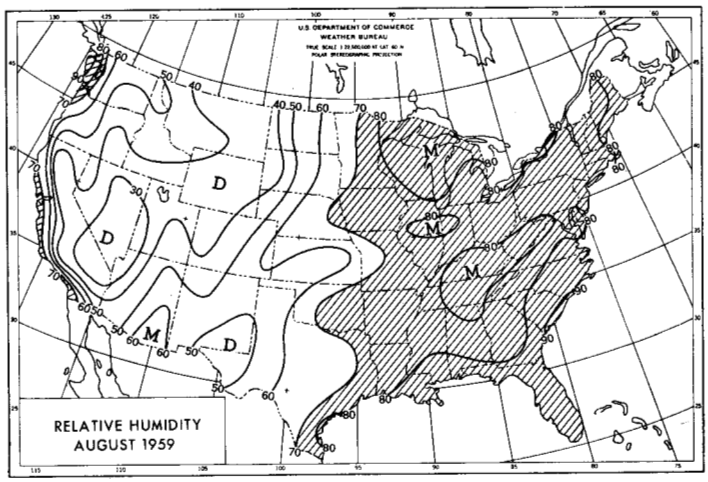

FIGURE 4.—Mean relative humidity for August 1959 based on the average of 0000 and 1200 GMT values. Very high relative humidities dominated the country from the Mississippi Valley to the Atlantic Coast.

tion of tropical air from the Gulf of Mexico and thus perpetuates warm temperatures.

Accompanying the heat wave was a regime of high relative humidity. This too was largely a result of low-level transport from tropical maritime source regions. Figure 4 shows the monthly mean relative humidities of the 0000 and 1200 GMT observations made during August 1959. Note that values greater than 70 percent (shaded) enveloped the country from the Mississippi Valley eastward. Also of interest are the low relative humidities in Montana and Wyoming, where the ground has been especially dry all summer.

2. EFFECT OF CHANGES IN MEAN CIRCULATION ON TEMPERATURES IN THE UNITED STATES

AUGUST 1–15, 1959

The mean circulation at 700 mb. over the United States during the first half of August was generally quite weak, as shown in figure 5A. Except along the northern border, where moderate westerlies prevailed, the gradient of 700-mb. height was seldom as much as 100 feet. Another feature of the chart, one which sometimes signifies an impending change, is the long wave spacing at 50° N. The next trough upstream from the one over Maine was at 165° W., a distance in excess of 90° of longitude.

The trough along the east coast was of considerable importance to the weather in spite of its small amplitude. Although not too apparent from the contours, this trough was the lower-latitude component of blocking. The higher-latitude component was evidenced by the +220-ft. height departure from normal off Labrador. Thus, easterly onshore flow prevailed along the Atlantic Seaboard from New England to Georgia.

Perhaps as a consequence of the generally weak flow, both observed and anomalous, temperature departures from normal for the first half-month were rather small in most of the United States (fig. 6A). Exceptions include the warm pockets in South Dakota, New Mexico, and the coast of California. In the last instance mean temperatures were more than 6° above normal. Portions of the Pacific Northwest and Arizona were nearly 3° below normal. Cooler than normal temperatures in the East were confined to coastal areas.

AUGUST 16–30, 1959

Broadscale readjustment of the circulation characterized the last half of August in and near North America. Figure 5B shows well-organized centers of action and substantial centers of height departure from normal. Anticyclonic conditions in the Gulf of Alaska replaced the generally cyclonic conditions observed there a half month earlier, with heights rising as much as 480 feet. Associated with this strengthening ridge, a strong trough appeared downstream over the western United States.

Marked cooling became associated with the trough in the West, and widespread heating accompanied intensification of the ridge in the East. The extent of the heating and cooling are portrayed in figure 6B.

Cold air penetrated into the interior valleys of California where temperatures averaged more than 4° below normal, contrasted with 4° above normal during the first

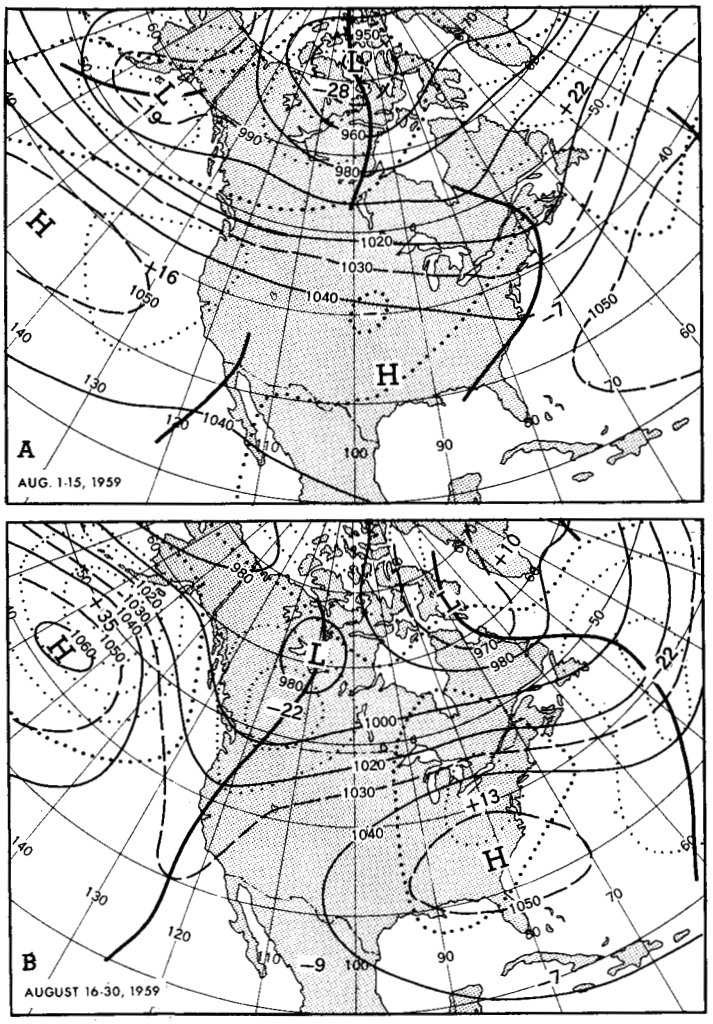

FIGURE 5.—Mean 700-mb. contours (solid) and height departures from normal (dotted) (both in tens of feet) for (A) August 1–15, 1959, and (B) August 16–30, 1959. Note the reversal of the circulation in the eastern Pacific and western North America as amplification occurred in the last half of the month.

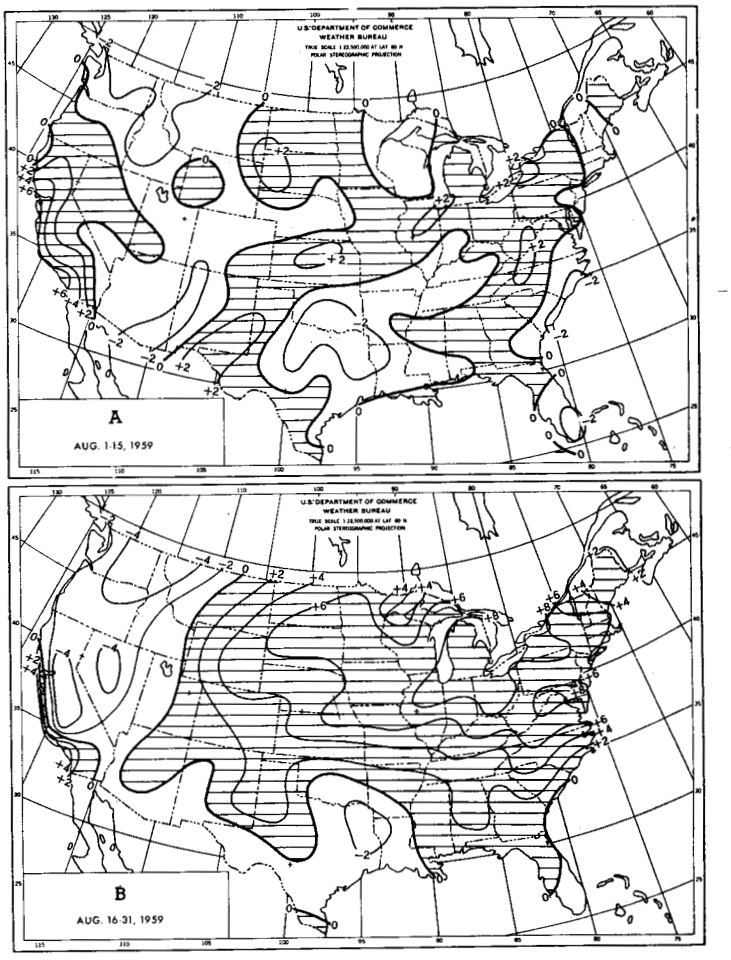

FIGURE 6.—Departure of average surface temperature from normal (°F.) for (A) August 1–15, 1959, and (B) August 16–31, 1959. Hatching indicates areas of normal and above normal temperature anomalies. Warming in the latter half of August was greatest in the eastern Great Lakes, and widespread in other areas east of the Rockies.

half of August. During the week ending August 24, temperatures of 10°–20° F. below normal were responsible for new low daily maximum records [4].

The positive height anomaly center near the lower Great Lakes (fig. 5B) was also the seat of the maximum surface temperature departures from normal (fig. 6B). Lower Michigan and northern portions of Illinois and Indiana recorded mean temperatures for the last half of August greater than 9° F. above normal. It was during this period that Chicago equalled an existing record of 11 consecutive days with 90° F. or above. Cincinnati had only three days out of the last 16 days of August in which the maximum temperature fell below 90° F. The Dakotas had numerous readings above 100° F.—to as high as 112° F. at Vivian, S. Dak.—during the week ending August 24 [4].

No storm centers penetrated the Eastern States from August 16 to 31, thus permitting an uninterrupted heat wave. The principal storm track was near Hudson Bay and was reflected aloft as the channel of negative height departures in that area (fig. 5B).

The temperate westerly index[2] is frequently a satisfactory reflection of the circulation. In August the behavior of the index was reasonably descriptive of the long-wave evolution near North America. The index reached a maximum of 9.1 m.p.s. (the highest since early June) for the 5-day period ending August 15. That was the termination of a generally rising index the first fifteen days of the month. Coincident with amplification of the trough in western North America the index started falling, and by the end of the month reached 4.8 m.p.s., more than 2 m.p.s. below normal.

[2] Computed at 35°–55° N. from 5° W.–175° E.

3. NON-PERSISTENCE OF TEMPERATURE ANOMALIES

A 16-year record shows that July and August are more persistent in terms of temperature anomaly than any other pair of months. Namias [5] found that in the period from 1942 to 1957 the change in temperature anomaly from July to August did not exceed one class at 82 percent of 100 stations in the United States. The other 11 months averaged a change of one class or none in 67 percent of the cases.

Temperature anomaly changes by class from July to August 1959 are shown in table 1. Persistence is defined as the total number of cities with no change in temperature class from the preceding month or with a change of only one class (either warmer or colder). From the table it can be seen that, with this definition, August 1959 had an index of persistence of only 54 percent. This exceptionally low figure can be compared with all the Augusts since 1942 on the accompanying graph (fig. 7). From 1942 through 1958 only August 1947 (hot in the East) and August 1958 (hot in the West) had persistence values below the random curve.

The geographical distribution of temperature anomaly changes from July to August is shown in figure 8. Areas of persistence are those without shading or hatching. The wide hatching depicts changes of two or more classes and, to some extent, is indicative of the heat wave. The four-class change in the Central Plains States is an area in which much below temperature anomalies in July were replaced by much above anomalies in August.

Persistence in temperatures does not necessarily imply a persistence of upper-level pattern. However, a month in which the temperature anomaly is particularly non-persistent is almost always associated with a major circulation change from the preceding month. In the present instance a reversal in circulation in the last half of August (discussed above) was responsible for a change of the whole monthly pattern from July to August.

4. OTHER ASPECTS OF THE CIRCULATION AND WEATHER

Figure 2 shows that the Low in the western Siberian lowland was the only vortex on the map whose monthly mean 700-mb. height was appreciably below normal. Even the long-wave troughs were relatively weak, and some were actually above normal in height. The trough in western North America was the strongest in the Western Hemisphere, and the one east of the Urals was the most vigorous on the map. In general, polar latitudes were under the influence of blocking, as attested by the widespread positive height anomalies in that area. Middle latitudes were moderately zonal. For example, in the western sector of the Northern Hemisphere, the 700-mb. zonal index of temperate westerlies was 1–2 m.p.s. below normal most of the month and increased to normal near the end of the month.

Although the Tropics were predominantly below normal in 700-mb. height, tropical storms were not especially active. In the North Atlantic (including the Gulf of Mexico and the Caribbean) tropical development was slight in August, as only one tropical depression managed to develop into a tropical storm. An easterly wave strengthened in the Lesser Antilles was designated Edith, then weakened as it moved westward. A week later the easterly wave brought heavy rains to the Texas coast, where the depression first deepened slightly then weakened again as it moved rapidly inland. The probability of tropical storm development in the North Atlantic in August is 1.6 storms per year according to Dunn [6]. (A later computation based on nine more years of data increased the average to 1.8 per year [7]).

On the other hand, in the western North Pacific there was greater than normal tropical storm activity. There has been an average of 4.6 storms per year in August [6], but this year 6 were found. Of those, there were five typhoons and one tropical storm. One hurricane in the eastern North Pacific was destructive on the island of

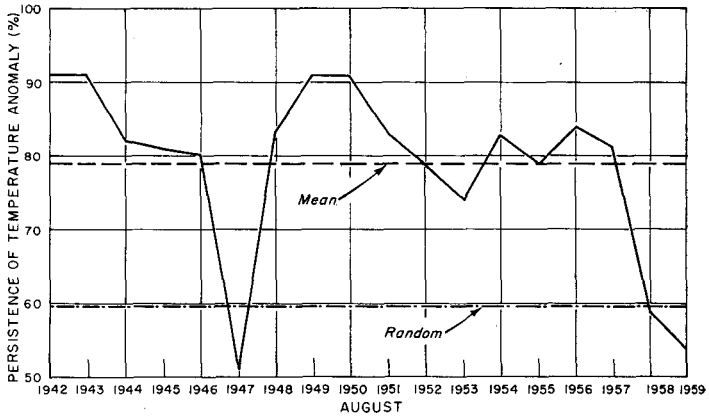

FIGURE 7.—Persistence of temperature anomalies (percent) from July to August 1942–1959. August normally has the highest persistence of any month averaging between 70 and 90 percent. In 1959 August was unusually non-persistent. Only August 1947 was less persistent.

TABLE 1.—*Class changes of surface temperature anomalies in the United States from July to August 1959*

Class change	Frequency (percent)
+4	3
+3	7
+2	18
+1	23
0	22
−1	9
−2	16
−3	2
−4	0

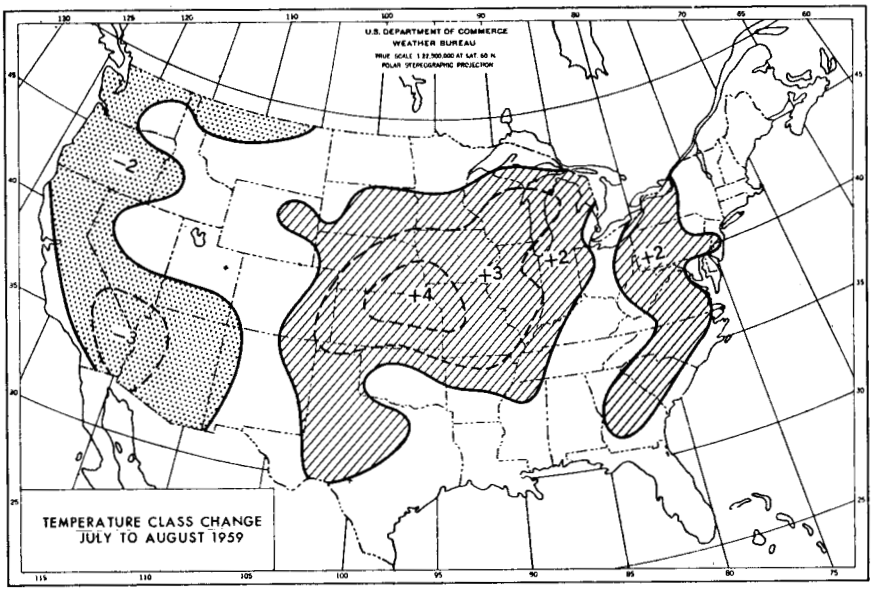

FIGURE 8.—Change in class of temperature anomalies from July 1959 to August 1959. In unshaded areas temperature anomalies did not change by more than one class; hatched portions represent a warming of two or more classes; and stippled areas denote a cooling of two or more classes. The temperature reversal in the Central Plains States and in Southern California contributed most to the non-persistence of August.

Kauai, Hawaii. Rain at Lihue was 8.13 in. for the month, almost 6 in. in excess of normal.

Precipitation in the United States (fig. 9) not directly attributable to local tropical developments was rather chaotic, but many features could be partially explained by physical considerations implicit in the monthly mean circulation at 700 mb. (fig. 2). For example, rainfall amounts in Oregon and Idaho were as much as three times normal under faster than normal westerly flow in advance of the mean trough lying near the coasts of Washington and Oregon. In a similar manner, upslope cyclonic flow at more northerly latitudes contributed to a total of 10.57 in. of rain at Annette, Alaska, which was more than 5 in. above normal. East of the Continental Divide the westerlies produced foehn drying. In Montana and Wyoming observed precipitation totals were less than 25 percent of the monthly normal (fig. 9) in a large area. Glasgow reported that August was its sixth consecutive month with below normal precipitation [4], and Billings recorded its driest May through August since 1894 [4].

A belt of generally heavy rain extended from the Dakotas to New England, and paralleled the axis of maximum frontal activity in August, along which there were 15–25 days with fronts. Of additional interest is the mean flow (fig. 2) which shows confluence (and thus frontogenesis) in that area, along the boundary between tropical and maritime polar air masses. Note also that mean 700-mb. height anomalies were positive, a condition usually associated with less than normal rainfall. Perhaps more surprising was the liberal distribution of heavy rainfall in many portions of the heat wave zone, since hot weather usually goes with dry conditions.

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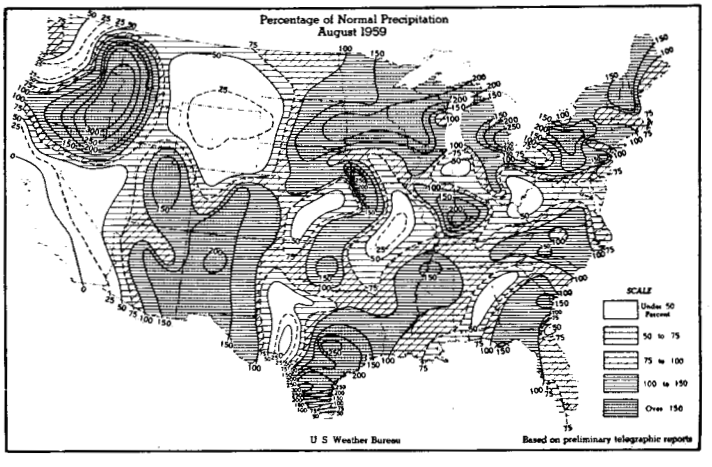

FIGURE 9.—Percentage of normal precipitation for August 1959. Note the discontinuous nature of precipitation greater than normal which occurred south of the Lakes and east of the Rockies. (From [4] Sept. 7.)

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7. U. S. Weather Bureau, "Hurricane Forecasting," *Forecasting Guide No. 3*, Washington, D.C., April 1959, 180 pp.

CORRECTION

Monthly Weather Review, vol. 87, No. 7, July 1959, p. 269: In column 2, first complete paragraph, change −99.9° C. to −90.9° C. The sentence should read, "The lowest temperatures registered during this ascent were: −89.5° C. (−129.1° F.) at 17,000 m. on the way up, and −90.9° C. (−131.6° F.) at 16,500 m. on the way down."

U. S. GOVERNMENT PRINTING OFFICE: 1959